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A CLIMATOLOGIST'S ROUND-THE-WORLD VOYAGE

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INTRODUCTION

"Field work" is as important in the study of the atmosphere as it is in geology, or in botany, or in physiography. Simple noninstrumental and instrumental observations of weather and climate may easily be made by any traveler who is interested in "snapshot" studies of atmospheric conditions and phenomena and who aims to be something more than a mere "globe-trotter." Such "snapshots" add very greatly to the interest of any journey, especially of an extended one to new oceans and new lands. Furthermore, they are distinctly instructive and often furnish a proper setting for much of the historical, economic, ethnographical, and even literary background of the regions visited.

It is, of course, obvious that a student, and still more a teacher, of meteorology and climatology will profit most by such field work. In fact, he should undertake it whenever and wherever possible. However well a teacher may know his text-books, he can never really appreciate other climatic conditions than his own unless he has had the opportunity of observing these conditions for himself. Only by this method can he have real confidence in what he is trying to impart to his classes. A geologist travels, often over great distances, in order to visit some typical rock formation, or a well-known volcano, or a famous mine. A botanist must go far afield from his laboratory to see some special plant form in its ideal development or to study peculiar environmental influences. An astronomer must travel to other latitudes than his own if he is to see planets and stars not visible at home. Similarly, the student of the earth's atmosphere must travel if he is to have first-hand knowledge of his subject. He will take advantage of every opportunity to travel; to see and to have personal experience with as many varied types of weather and of climate as he can. He will plan his journeys so that they will take him to localities where there is something of special and peculiar interest in the way of some particular type of meteorological phenomenon or some outstanding climatic feature.[1]

The writer has, on numerous journeys, found instruction, interest, and real inspiration in "snapshot" studies of weather types and of climatic characteristics. His own experiences have been so helpful to him as a teacher that he has not hesitated to publish the very simple results of his travels in the hope that others might thereby be stimulated to carry out similar observations.[2] It was the late Ralph Abercromby's delightful volume, "Seas and Skies in Many Latitudes, or Wanderings in Search of Weather," which, 40 years ago, gave the present writer his first inspiration for carrying on the same general sort of simple meteorological observations which the author of that book so interestingly described and so faithfully completed.

A leave of absence during the second half of the academic year 1928–29 brought the opportunity, long hoped for, of making a round-the-world voyage. A previous trip had covered a north-south cross section of the atmosphere, from New York down the east coast of South America, through the Straits of Magellan, and then up the west coast, across the Isthmus of Panama, and back to New York. It had long been the writer's desire to travel east and west around the world in order that he might complete his first-hand knowledge of the great wind belts in other oceans than those across which he had previously sailed. For this purpose he chose the Dollar Line, which sends out a ship from New York every two weeks on a regular voyage westward around the world via the Panama and Suez Canals. The steamer, the *President Monroe*, left New York, on her seventeenth

[1] See R. DeC. Ward: The Importance of Field Work in the Study of Climates, Proc. Amer. Philosoph. Soc., vol. 64, No. 1, 1925, pp. 64–77.

[2] See, e. g., R. DeC. Ward: Notes on Weather and Climate Made During a Summer Trip to Brazil, 1908, MONTHLY WEATHER REVIEW, vol. 36, October, 1908, pp. 333–339; The Economic Climatology of the Coffee District of Sao Paulo, Brazil, Bull. Amer. Geogr. Soc., vol. 43, June, 1911, pp. 428–445; Two Climatic Cross-Sections of the United States, MONTHLY WEATHER REVIEW, vol. 40, December, 1912, pp. 1909–1917; A Proposed Guide-Book to the World's Weather and Climates, Proc. Amer. Philosoph. Soc., vol. 67, No. 1, 1928, pp. 67–94.

round-the-world voyage, on February 14, 1929, and returned on May 28, with stops at 19 ports en route.[3]

The instrumental equipment taken was intentionally very simple, because the voyage was made chiefly for the sake of rest and health, and it was not the desire of the writer to burden himself with too much routine. There were but two instruments: A small-size Richard barograph and a pocket sling psychrometer. The former, which had previously served faithfully on three voyages to South America and on the International Ice Patrol in 1923, was hung from the ceiling of the stateroom by a spiral spring. The pocket sling psychrometer was a small-size instrument in a brass case, 7 inches long, and was both convenient and useful. The latest United States Hydrographic Office pilot charts of the North Atlantic, Central American Waters, North Pacific, and Indian Oceans were also taken. These were cut up and mounted on linen for convenience of use.

Three general rules should constantly be borne in mind when making such traveling "snapshots" of weather and climate. First, it is highly desirable to make one's own observations wholly regardless of any previous knowledge of the meteorological conditions of the localities visited; in other words, to be wholly open-minded in the matter. If one expects to find something, the chances are that he will find it, and such an attitude of mind is prejudicial to accurate observation. Second, but little weight should be given to what the local residents may tell the traveler about the weather at the time of his visit. It is but natural that people who live in a place should wish to have travelers carry away favorable impressions. Hence the constant recurrence of statements that "it is unusually rainy," or that "there never was so dry a spell in the memory of the oldest inhabitant," and other similar remarks. All such expressions, which are really the result of local pride, ought to be taken with many grains of salt. Third, it should be remembered that, on any hurried trip, the weather types experienced are to be associated with the special time and season of the traveler's visit, and they must not be overemphasized as dominant and permanent characteristics of any climates which have reasonable seasonal variety.

It would extend the present descriptive account far beyond any reasonable limits if any attempt were made to include even half of all that was seen and learned by the writer on a voyage which was crowded with innumerable details of interest and scientific profit. In what follows the object has been to bring out the outstanding facts only and to arrange them in such a way as may make them most useful to other round-the-world travelers, and especially to those who are desirous of obtaining vivid impressions of the major characteristics of the weather and climates which may be observed on such a trip as that which it was the writer's good fortune to make.[4]

[3] Habana, Cristobal, Balboa, Los Angeles, San Francisco, Honolulu, Kobe, Shanghai, Hong Kong, Manila, Singapore, Penang, Colombo, Suez, Port Said, Alexandria, Naples, Genoa, and Marseilles.

The *President Monroe* is an oil-burning American steamship, length 522 feet 8 inches, 10,533 gross tons, and 6,000 horsepower. She was built for the U. S. Shipping Board Emergency Fleet Corporation during the World War.

[4] As a convenient and highly condensed summary of the general meteorological conditions at sea throughout the voyage the following description may serve: Changeable weather, with some storms and rough seas, was experienced in the prevailing westerlies (1) soon after leaving New York on the trip to Habana; (2) after leaving San Francisco on the way to Honolulu; (3) before reaching Kobe; (4) on the voyage from Gibraltar to New York. On the other hand, in the trades and in the monsoon belts, fine weather, smooth seas, brilliant sunshine, and light to fresh winds characterized the voyage from one day out of Hong Kong as far as Suez. The Mediterranean was intermediate between these two extremes. The temperature condititions may be summarized as follows, in terms of the need of artificial heat or of electric fans, and of heavier or lighter clothing: Steam heat, blankets, and heavy clothing were needed (1) for two or three days after leaving New York; (2) a few days before and after leaving San Francisco; (3) a few days before and after leaving Kobe; (4) two days on the homeward stretch between Gibraltar and New York. Light clothing and electric fans were necessary before reaching Habana, through the Panama Canal, and part of the way from the canal to San Pedro. The thinnest of clothing ("whites") and the constant use, night and day, of electric fans were necessary soon after leaving Hong Kong and all the rest of the voyage as far as the end of the Suez Canal. The temperatures in the Mediterranean were intermediate.

NEW YORK TO HABANA, FEBRUARY 14–18 (1,186 NAUTICAL MILES)

Northeast storm signals were flying on the bleak, overcast afternoon in mid-February when the *President Monroe* sailed on her long voyage. Her southward course, to Habana, carried her toward the approaching storm, and around the eastern side of the center. A day of smooth sea and light breezes was followed by a southeast gale, with heavy rain, rising temperature, and a rough sea. The barograph curve showed the passage of a primary and then of a secondary center of low pressure, followed by a gradual rise. There was no clearing between the two depressions, and the secondary was accompanied by violent westerly squalls, with vivid lightning. That was a long voyage, much of it to be spent in the uniform conditions of the Tropics, appropriately begun in a marked winter cyclonic storm of the prevailing westerlies. The ship's "Radio News" reported that Col. Charles A. Lindbergh, flying back from Central America, was forced down at Cape Hatteras Inlet "after a battle to get around the storm area." Variable winds, mostly westerly, partly cloudy skies, and rising temperature followed.

The diurnal variation of the barometer began to be noticeable, although faintly, the third day out, in about latitude 27°. Steaming southward off the southern coast of Florida at night, the long lines of electric lights on shore, concentrated here and there in the fashionable winter resorts, suggested the importance—economic as well as social—of the steep winter temperature-gradient along the Atlantic coast of the United States. Semi-tropical Florida, with its far-famed winter resorts, is only a few hours by rail from the great cities of the north. This rapid southward increase in temperature was strikingly illustrated by the successive noon temperatures: 52°, 68°, 72°, starting in New York with 32°. Approaching the coast of Cuba, the wind began to blow from the east. The northern limit of the northeast trades had been reached. The month being February, the trade limit was at about its farthest southern position. Habana, where an afternoon and evening were spent, calls to mind a wonderful tropical sunset with golden upper edges of far-away cumulus clouds; a rapid upward growth of the cumulus clouds after sunset, doubtless the result of radiation from their upper surfaces; a brilliant winter season afternoon, with a light easterly wind. Temperatures at Habana were 75° to 80°. The position of the city, and of its harbor, made it easy to realize the danger to shipping which a strong *norther* has occasionally brought to that port.

HABANA TO CRISTOBAL, FEBRUARY 19–21 (1,000 NAUTICAL MILES)

The three days from Habana to Cristobal brought the delights of steaming in the northeast trades, with a light to fresh breeze (mostly due easterly) tempering the heat (75° to 83°), smooth sea, and brilliant sunshine. Voyaging in West Indian and Caribbean waters inevitably emphasizes the wonderful meterological advantages enjoyed by the early Spanish pioneers on their trips to and from the New World. Except in the hurricane season, fine weather, stormless and fogless, was the prevailing condition over these seas, and one can not help speculating as to the historical consequences if Spanish and Portuguese had been forced to sail to and fro across the stormier portions of the Atlantic and Pacific in their contact with Central and South America and the West Indies in the early days. To anyone whose eyes are open

to the phenomena of nature there is variety even in the apparent monotony of the trades. However steady may be the wind, there is change in the sky. There are the slender columnar trade cumuli, increasing at times to small cumulo-nimbus, and then breaking up toward sunset; occasional flocks of alto-cumuli; not infrequently also the formation of a sheet of high stratus after sunset, probably due to radiation upward from the lower stratum of damp air over the ocean. This stratus "burns off" in the morning sun.

PANAMA CANAL, FEBRUARY 22 (38 NAUTICAL MILES)

A beautiful "winter" dry-season day marked the passage through the Panama Canal, with temperatures 80° to 85°; relative humidity 70 to 80 per cent; small cumulus clouds increasing here and there to cumulo-nimbus in the warmer hours, but without showers at the place of observation; an easterly wind, with the highest velocity at the northern entrance to the canal, weakening over the land, but always strong enough to make the damp tropical heat perfectly bearable unless one were in the sun or exercising. The strong onshore trade wind at the northern end of the canal, with massive cumulus clouds even early in the morning, brought to mind the heavy rainfalls of the windward slopes of the Isthmus as compared with the relatively lighter precipitation on the Pacific side. This condition, characteristic of most of Central America, resulted, even in early times, in the more extensive settlement of the drier and more open lee coasts and slopes, and the abandonment, to a considerable extent, of the wetter and densely forested windward slopes. The diurnal variation of the barometer, characteristic of several days past, showed very distinctly the irregularities in pressure due to the changes in height above sea level during the passage through the locks in the Panama Canal. The highest level (Gatun Locks and Gatun Lake) was indicated by the pressure readings after the 10 a. m. maximum, the barometer later falling to a lower 4 p. m. minimum than had previously been recorded on the voyage. This feature, which must certainly have been observed hundreds of times during the passage through the canal, has not, so far as the writer knows, hitherto received mention in meteorological literature. The rather sudden changes as the steamer descended through the locks from the Gatun Lake level were clearly shown on the barograph curve.

Thirty-one years had passed since the writer had been on the Isthmus. At that time, work on the canal was being carried on by the reorganized French Panama Canal Co. The contrast in conditions, then and now, was overwhelming. Two impressions were forced home. One was of the stupendous amount of work done by the United States in the completion of the canal. But back of this was also the memory of a very considerable accomplishment, nowadays rarely recognized, by the French. The writer's memory of the Culebra Cut in January, 1897, is that it was already then a very deep wedge cut out of the mountain, and no inconsiderable portion of the canal near sea level on the Caribbean side was then practically ready for use by small vessels. Reduced to its very lowest and simplest terms, it is true that the Panama Canal is "nothing but a dammed-up river; an artificial lake; a deep cut through a mountain; a great flight of steps up and down from the Atlantic to the Pacific." That is all. But the overwhelming marvel of it all is that the gigantic task—the dream of centuries—has been accomplished, and smoothly and quietly thousands of ships annually pass to and fro.

The broad screened verandas of the houses in the Canal Zone bring to mind the wonders accomplished in the eradication of malaria and yellow fever, and quite naturally lead the *casual* traveler to the view that the conquest of the Tropics as a place of residence for the white race has been accomplished. This is very far from the truth. Here in the Canal Zone, in Cuba, in the Philippines, in parts of South America, of Africa, and elsewhere, almost unbelievable wonders have been performed by modern sanitary and medical methods. But these points are hardly more than pin pricks in a map of the Tropical Zone. To carry such a campaign through successfully over the whole of that vast area would mean an expenditure so great as to be almost unthinkable. Furthermore, over many sections of the Tropics, all modern sanitary precautions are met with hostility on the part of the native population, and must be put through and maintained by military or very strong civil authority. The day is still very far distant when tropical diseases will disappear. The Tropics have not been conquered for the white race from the standpoint of acclimatization. And there are many reasons for believing that even if every tropical disease were forever eliminated successive generations of white men could not live in the hot, moist Tropics without serious mental and physical degeneration.

BALBOA TO LOS ANGELES, FEBRUARY 23–MARCH 3 (2,913 NAUTICAL MILES)

From the Pacific terminus of the canal to the port of Los Angeles the prevailing characteristics were smooth seas; light to fresh variable winds, mostly northwest and northeast; clear skies, and some calms. For the first few days air temperatures averaged 80° to 83°, and water temperatures 80° to 84° in the warm current flowing northward along the coast. Off the southern end of the Gulf of California came a sudden change. With a fresh northeast wind the air temperatures fell 10°; and the cold southward-flowing ocean current, so important a climatic control along the southern Pacific coast of North America, brought water temperature also 10° or more lower. Blankets again appeared on beds and overcoats on deck. For much of the trip the coast of Central America, and then of Mexico and Lower California was visible. While a few cirrus were the characteristic clouds at sea, cumulus was often seen over the land. On three or four days when the wind was northeast, i. e., offshore, a distinct diurnal variation in its velocity was observed. This was obviously a land effect carried a few miles out over the ocean. There is very little, if any, diurnal variation in the velocity of the wind far from land. The course immediately after leaving Balboa carried the *President Monroe* too far north to bring her into the area of the southwest winds which, in February, blow as far as about 5 degrees north of the Equator over the ocean to the west of the Bay of Panama. These southwest winds are really monsoonal in character, and are analogous to the southwest monsoon off the west coast of Africa (Gulf of Guinea). The northern limit of the southeast trades in February is just about on the Equator in the Pacific Ocean west of northern South America.

During the warmer months of late summer and autumn occasional storm winds, with heavy rains, are encountered on the route between the Canal Zone and southern California. These belong to that interesting and, until recently, little-known group of tropical cyclones of the eastern North Pacific which, because they develop and spend most of their life in a part of the ocean which is

not much frequented by vessels, have received little attention until within a very few years. The general rise in the barograph curve during the voyage northward showed the approach toward the axis of the North Pacific anticyclone, and the less and less marked diurnal variation with increasing latitude (25° to 30° N.) was another characteristic. Progressing northward, both water and air temperatures fell, the water (noon) to 66° and then to 64°; the air, at various hours, to 65° and later to below 60°. Good views of the coast of Lower California, and of the islands offshore, gave striking evidence of the almost negligible rainfall over these lands, in the sparseness or absence of vegetation, the arid-land topography, and the absence of human settlements. The landscape recalled parts of the western coastal desert of South America, an analogous climatic region, under similar controls.

Los Angeles, March 3–4.—A typical fine winter day in Los Angeles was marked by clear sky, light westerly wind, and a range from 70° (maximum) to 48° (minimum). The warmth of the noon hours was followed by a crisp, chilly evening. Blossoms on the trees; garden flowers in profusion; vegetables of many kinds; and lucious oranges weighing down the branches in many orchards, served as cheerful reminders of the mild winter climate of the southern California coast, where so many thousands from the colder and less hospitable climates of the north and east have found health, and a new joy in living. Even the casual and hurried visitor is impressed by the climatic advantages of sunny southern California.

LOS ANGELES TO SAN FRANCISCO, MARCH 4–5 (368 NAUTICAL MILES)

The run from the port of Los Angeles (San Pedro) to San Francisco, short as it is, gave a vivid illustration of the well-known and much-dreaded fog, so characteristic of this coast, especially in summer. With the prevailing wind from the westward blowing across the cold water of the California current, cooling to the stage of fog formation is a natural result. Cold ocean currents and fog are associated in all parts of the world. The blowing of the steamer's whistle at intervals during the afternoon and evening served to emphasize the critical importance, from the point of view of navigation, of the Pacific coast marine fogs. Later, a typical "high fog" followed, reminding the writer of the analogous "coast cloud" which he had seen day after day on his voyage along the desert west coast of South America 32 years before. From central Chile to northern Peru the general climatic régime is extraordinarily like that from San Francisco to southern California. The major climatic controls are essentially the same. The decrease in rainfall from higher to lower latitudes is the same. The season of rainfall is the same. The economic and human responses are largely the same.

San Francisco, March 5–8.—The first day in San Francisco was termed at the United States Weather Bureau "a normal day" for the season. During the 24 hours preceding the maximum temperature had been 57° and the minimum 51°, without precipitation. The morning, (5 a. m.), map showed a well-developed cyclonic disturbance, (29.30 inches), covering the Gulf of Alaska and extending southward along the Pacific coast along the eastern margin of a HIGH central about latitude 40° N., well out on the ocean. During the last 24 hours rains had fallen in Washington and western Oregon. The forecast for the San Francisco Bay region was: "Cloudy and unsettled" for the night and the following day, "probably followed by rain; moderate temperature; moderate west to south winds." The pressure was falling along and off the Pacific coast, and rains were forecast on the following day in extreme northern California. Southeast storm warnings were being displayed on the coasts of Oregon and Washington. The type of map was one generally favorable for rain along the northern coast. Two days before a significant change in the general pressure situation had occurred. The anticyclone which had for some weeks impinged on or overlain the Pacific slope had retreated westward toward the central portion of the ocean, while a low-pressure trough was developing along the coast. The conditions were changing from dry weather to those more favorable for rain.

The next day's map showed a further deepening of the Gulf of Alaska depression (28.90 inches); a southeastward movement of the disturbance, and the extension of light rains down the coast as far as the San Francisco Bay region, with unsettled and cloudy weather over the whole area west of the Continental Divide. The 5 a. m. forecast was for unsettled with occasional rains that night and the following day, with mild temperature and moderate southerly winds. The maximum and minimum during the previous 24 hours were 57° and 52°, respectively. Southeast storm warnings were displayed on the coasts of Washington and Oregon. Without any notable change in the pressure, rain began in San Francisco about noon, and fell intermittently, giving 0.20 inch for the day. This brought the seasonal precipitation to 12.06 inches, 5.07 inches short of the normal. Rain fell throughout the Sacramento and San Joaquin Valleys, and although the amounts were not large, these showers meant millions of dollars to the agricultural interests. The seasonal rainfall throughout the State was only about 50 to 60 per cent of normal up to date. Mr. T. R. Reed, the local forecaster, stated: "The crop situation upstate is very grave. Another three days without rain would result in almost total ruin for San Joaquin's grain crops. In the Sacramento Valley the crops might have lasted a week without moisture, but not longer." Another serious condition was the scarcity of snow in the Sierras. At Summit there were only 36 inches of snow on the ground. In normal years the depth is 115 inches. While the grain growers were suffering from the deficiency of rain, the deficiency of snow indicated a very serious situation during the coming summer because of the diminished supply of water for irrigating the citrus, deciduous, and nut crops. Thus, although the writer had only two days in San Francisco, he came at a critical time, meteorologically. The vital importance of the rain and snow in relation to crops and general economic conditions was strikingly emphasized. As Mr. Reed truthfully stated, "every 0.01 inch of rain means thousands of dollars in the bank for California farmers."

When the voyage was resumed from San Francisco, there were indications of a further disintegration of the anticyclonic system over the Pacific and of more rain from low-pressure conditions over the northern Pacific coast, whose influence would reach southward into California. The temperatures on the second day in San Francisco (overcast; followed by rain) varied between 59° (maximum) and 52° (minimum).

Few, if any, parts of the world can offer more numerous, or more striking, illustrations of direct economic effects of meteorological conditions than does California. Here the winter snows of the high Sierras have well been called "the lifeblood of the State." Here the amount of the annual rainfall is of supreme importance in agriculture, in water supply, in water power. The frost-fighting cam-

paign in the citrus districts of southern California has reached a degree of development unknown elsewhere. The critical importance of the frost forecasts, and of rain forecasts, is a constantly increasing responsibility of the Government Weather Bureau. A rain, not forecast during the outdoor fruit-drying season in the Great Valley, may mean the loss of millions of dollars. The forest-fire weather forecasts, a relatively recent development, are every season becoming more valuable in the prevention and fighting of forest fires. And here, in the district between Los Angeles and San Francisco, has lately been inaugurated a new intensive meteorological service in the interests of aviation, supported by the Daniel Guggenheim Fund for the Promotion of Aeronautics, with additional financial assistance for certain powerful commercial and industrial interests, and also supported and effectively directed by the Weather Bureau.

With frequent observations of weather conditions along the airways, and with the development of radio communication with airplanes in flight, California is doing splendid work in making aviation safer and surer. Maj. E. H. Bowie, of the United States Weather Bureau in San Francisco, gave the writer an interesting set of maps showing the distribution of "tule" (radiation) fog in the San Joaquin Valley on a recent winter day. These charts, based on observations made at intervals of 90 minutes between 6:30 a. m. and 3:30 p. m., show very clearly the change in the extent and location of the fog belt during the day. These tule fogs, fortunately not daily phenomena, may attain a vertical thickness of over 1,000 feet, and sometimes last through the whole day. They are obviously a serious handicap to the mail and other planes. The more detailed the available information regarding all fogs and other meteorological conditions of concern to the aviator, the more rapid will be the progress of aviation. Another interesting development in California is the use of a meteorological and radio station traveling on a truck during the forest-fire season. This portable station receives all the regular official reports of meteorological conditions, both from land stations and from vessels. The observer in charge takes his own local observations, makes his own weather maps, and then distributes all available information to the men who are fighting the fire, thus making the task of subduing the fire more effective, because more intelligently directed. This plan was first tried in the summer of 1928, and was to be put into regular operation in the summer of 1929, as reported to the writer by Maj E. H. Bowie in March, 1929.

SAN FRANCISCO TO HONOLULU, MARCH 8–15 (2,091 NAUTICAL MILES)

It seemed a fitting send-off to a ship which was leaving the belt of the prevailing westerlies for a long voyage in the trades and the monsoons that the first two days of the voyage from San Francisco to Honolulu brought a clean-cut example of a North Pacific winter storm. The barograph curve showed a fairly rapid fall (to 29.65 inches). Strong southwesterly winds and a disturbed sea were followed by westerly winds of gale force, and then by a sudden change to a northwesterly gale, accompanied by heavy squalls with rain and some snow. This storm was apparently a development in the general low-pressure trough along the eastern margin of the North Pacific HIGH, previously noted on the San Francisco weather maps. Over the radio on the evening of March 9 came the news that much-needed rains were falling in California, with snows in the Sierras. The storm was followed by a decreasing northwest wind and calmer sea. Temperatures varied between 52° and 56° on the first two days, with the water as low as 50°. The days following the storm are readily summarized: Smooth seas, variable winds, westerly and then mostly southeasterly (force 4); cirrus and small cumulus clouds (0.1 to 0.4); rising barometer until the axis of the high pressure area was passed in latitude 32° N. (30.35 inches), and then, with the diurnal variation again coming in (about latitude 30° N.) falling very slowly as lower latitudes were reached. The northeast trades began to blow (E) about 24 hours before reaching Honolulu, almost exactly at the latitude shown on the pilot chart, with the familiar forms of trade cumulus, and the sea just roughened enough to give small white caps. The air temperatures rose slowly from 50° to 55° at San Francisco to a few degrees over 70° when the Hawaiian Islands were reached, and the water temperatures rose from 56° to 72°.

Most meteorological textbooks overemphasize the horse latitude calms. It is true that the chances of finding calms are greater there than in the "heart" of the trade winds, for example, but any pilot chart will show that there is wind most of the time, variable in direction, but averaging force 4 or 5. It should be remembered that the horse latitudes are not a broad belt, well defined, stretching evenly across the oceans, but rather relatively small oval areas of high pressure, unsymmetrically located in relation to the central portion of the oceans. The storm winds of the prevailing westerlies increach upon these high-pressure areas on their polar margins, while on the equatorward side blow the trades. There is no insignificant number of gales on the polar margins of the horse latitudes. Variable winds, not infrequently of considerable velocity, and not calms and very light winds, are really the prevailing condition. The rather sudden increase in cloudiness about and after sunset was also observed on numerous occasions. This was noted both in an upward growth of the cumuli, and also in the development of stratus. The cause is doubtless to be found in the active radiation, after sunset, from the upper surfaces, either of the clouds themselves or of the lower stratum of damp air overlying the ocean.

Honolulu, March 15.—Many memories of the day in Honolulu will linger in the memory of the writer: Memories of red, white, and pink oleanders, of brilliant purple and red bougainvilleas covering arbors and trellises; of gorgeous poinsettias and poincianas, all growing in extravagant profusion in the gardens and along the streets of the city; of bananas, of sugar cane, and of pineapples; of white beaches, and of royal and coconut palms. Truly, "the Paradise of the Pacific" is well named. In the Tropics, yet, as it were, not of the Tropics, this favored island group, swept by the trade winds, suffers no extremes of heat or cold. It is blessed by nature in astonishing measure. Maximum temperatures are never as high as those experienced on many summer days over most of the United States, and sea-level minima are in the vicinity of 60°. On a very wonderful day in mid-March—the time of the writer's visit—the highest temperature was 80° and the lowest 68°, with the steady easterly trade wind blowing, and the sky flecked with scattering cirrus clouds except over the mountains behind the city. Over these hung a magnificent rampart of brilliant cumulus and cumulo-nimbus, piling up over the crest; dissolving on the lee (SW.) side, and at intervals giving short light showers—the "electric sunshine" of Honolulu.

The famous motor drive up the Moana Valley to the Pali, on the windward side of the mountains, gave a superb view over the green lowlands far below, and then,

in the distance, lay the brilliantly white coral sand beaches and, beyond, the blue Pacific. This short trip takes the traveler up from the drier, warmer, and calmer western (leeward) slope into the cool northeast trade, which blows, with wonderful steadiness and often with considerable velocity, up the eastern (windward) slopes and through this narrow valley down toward Honolulu. So strong is the wind at times that the road is closed, on account of the danger to travelers. The Hawaiian Islands have for years furnished famous examples of remarkable contrasts in rainfall within very short horizontal distances. The windward slopes of the mountains have heavy trade rainfall. Within a few miles, to leeward, there is aridity. On the crests of the mountains back of Honolulu there is an annual rainfall of about 200 inches. Somewhat down the western slope, in the valley, the amount is about 70 inches. Still farther to leeward, on the lowlands, the natural vegetation and the obvious need of water for gardens and lawns, furnishes unmistakable evidence of semiaridity. It has been said of Honolulu that every street has a different rainfall. The impression of Honolulu that will remain the longest is the view of the city from the harbor in the late afternoon, as the *President Monroe* sailed on her voyage to Kobe. All the lower slopes of the mountain background and the city itself were bathed in brilliant sunshine. But on the mountain crests was the great towering wall of cumulus and cumulo-nimbus clouds, apparently fixed, yet ever changing; the product of the forced ascent of the northeast trades, the beneficent rain bringers of "the Paradise of the Pacific."

HONOLULU TO KOBE, MARCH 15–28 (3,665 NAUTICAL MILES)

From Honolulu to Kobe the course lies somewhat north of west, through the much-advertised "Sunshine Belt to the Orient," so named because it is south of the stormier and cloudier latitudes followed by the steamers between Seattle and Vancouver and Japanese ports. This belt is, however, not all sunshine. Cloudy spells, associated with the cyclonic storms of the prevailing westerlies, encroach upon it, especially in winter. Two days of the "perfect" weather conditions of the northeast trade—smooth sea, brilliant sunshine, ever-changing trade cumulus, temperatures (73° to 78°) ideal for comfort because of the fresh breeze—were followed by a change to southeast and then to southwest winds as the northern limit of the northeast trade was passed, a transition which, on most charts, looks diagrammatic and rigid. When experienced at sea, this crossing from one wind belt to another inevitably brings to mind the great controls behind the prevailing winds of the world, and makes the atmospheric machine a vivid reality, far beyond the scope of any textbook description, however graphic it may be.

The passage out of the trade brought an interesting series of strong southwest, and later northwest, squalls, with heavy rains and a northwesterly swell coming from a storm to the northward, reported by radio from a passing ship on the northern route. The occurrence of these sharp squalls in such a latitude (24° to 25° N.) was unexpected by the writer, and his opinion that they were unusual was confirmed by the captain. The "squares" on the pilot chart in this vicinity showed only a very small percentage of gales in March. The diurnal variation of the barometer, although still apparent on the barograph curve, was greatly disturbed by sudden slight oscillations during these squalls, becoming less and less marked as higher latitudes were reached, and with continued irregular fluctuations. The diurnal variation disappeared in about latitude 30° N. The general pressure curve rose slowly, and then fell slowly. Neither rise nor fall was a rapid as in the Atlantic, or on the voyage from San Francisco to Honolulu, because the ship's course to Kobe took her almost along the axis of the North Pacific anticyclone, and not directly across it.

During the rest of the voyage to Kobe there were smooth seas; variable winds (force 3–5); cloudiness ranging from clear to overcast; two spells of general rain, the first one of which was not accompanied by any marked lowering of pressure, and temperatures, varying with the wind direction, between 60° and 70°, and gradually falling. Water temperatures varied between 78° and 62°. The second general rain, which occurred with strong southeast winds the day before reaching Kobe, was accompanied by a moderate depression of the barometer (28.85 inset).[5] The International Date Line (longitude 180°) was crossed March 19—the place where there is no to-morrow but only the day after to-morrow. March 20 was omitted. March 21, the day of the spring equinox, followed March 19. With the exception of the squalls and general rains above referred to, lasting for about three days in all, the weather on the voyage from Honolulu to Kobe was fine and the sea smooth—an unusual condition, considering the time of year (March).

Kobe, March 28.—Very picturesque was the slow approach to Kobe in a fog which gave the passing fishing boats the dim and misty outlines familiar through many Japanese prints, and showed the dock yards and tall chimneys of Kobe as faint silhouettes in the distance. The day was dull and overcast with a chilly westerly wind blowing (57° all day) and rain in the evening. The barometer was falling slowly to a moderate depression. A heavy winter overcoat was none too warm. During the night and on the following day the barometer rose and the sky cleared. There were, however, many cumulus clouds all day, and at intervals light sprinkles of rain fell, mostly during bright sunshine. The wind was northwesterly and the temperature continued low enough (52° to 54.5°) to make the day chilly while riding about town in a "rickshaw." The forecast issued by the Toyko Central Meteorological Observatory on the day of arrival at Kobe was: "Mostly cloudy to-night, with northerly wind. Fair but occasionally cloud, to-morrow, with northwesterly winds." The summary stated: "The weather is growing better. High atmospheric pressure hovers east of Japan and northern Japan."

Climatically, Japan is an unusually interesting region, and it would require much time and prolonged visits in many parts of the empire to give the traveler any adequate knowledge of its varied climates and changing weather types. Being a group of islands, there are many marine or insular characteristics. On the other hand, the proximity to the Asiatic coast brings continental types modified by the presence of the oceanic waters of the Sea of Japan to the west. The considerable latitudinal extension brings into sharp contrast the severe winters of the north and the tropical conditions in the far south. The western shores have more continental climates, somewhat resembling those of the Asiatic mainland. The northernmost island has deep, long-enduring winter snows. Snow also falls, far less frequently, over the other islands of Japan proper. Snow-capped Fujiyama is one of the glories of Japanese scenery and art. On the other hand, the mountains protect the eastern coasts from the

[5] The inset chart of gales on the March North Pacific Pilot Chart shows that gales occur, on the average, on 11 days out of 100 in the "square" where this storm was encountered.

extremes found on the west. Rainfall is sufficient everywhere—in many sections abundant. The varied topography insures considerable differences in rainfall, as well as in types of climate, both vertically and near sea level. The monsoon régime of eastern Asia extends over Japan. Hence the general summer rains, with the heaviest precipitation on the east and south. Winter brings the maximum precipitation on the west coast of Hondo, where the cold-season monsoon comes across the water on its way from the mainland, and there is much damp, cloudy, and foggy weather, while the east is clearer and sunnier.

Warm and cold ocean currents play a part in controlling temperatures and weather conditions, but, as in the case of the Gulf Stream off the eastern coast of the United States, the warm current to the eastward of Japan has relatively little influence in tempering the winters because the prevailing winds are offshore. Many extratropical cyclones are bred in close proximity to the Japanese Islands in winter and bring their usual accompaniments of unsettled weather, varying winds and rain. These storms bring no inconsiderable amounts of rainfall to eastern sections in the colder months.

KOBE TO SHANGHAI, MARCH 29–APRIL 1 (780 NAUTICAL MILES)

The first 200 miles of the voyage from Kobe to Shanghai are through the inland Sea of Japan, a charmingly picturesque body of water which lies between the three principal islands—Hondo on the north, Shikoku on the south, and Kyushu on the southwest—and is itself dotted with many small islands. Little fishing villages along the shores; scores of fishing boats with their square sails and bamboo yards; terraced paddy fields on the lowest slopes of the hills; pine trees, so typical of Japanese scenes, climbing higher up; blossoming plum trees adding bright spots of color—these are some of the more vivid memories of this unique sail. At the western end of the inland sea, Shimonoseki and other considerable settlements combine the picturesqueness of the older native village with the large manufacturing and other plants of more recent growth. Northerly winds brought a chill (45° to 50°), which necessitated heavy outside wraps and steam heat on board, and as the western end of the inland sea was reached the sky became overcast, emphasizing the fact, already referred to, that the west coast is more cloudy and rainy in winter than the east coast. The more abundant tree growth than in the vicinity of Kobe also suggested the heavier rainfall of the west coast. Passengers who expressed surprise at the cold forgot that they were in latitudes 34° to 35° N.; that northerly winds here were certain to bring cold, and that the continental climate of the coast of Asia was not far distant. The "zigzagging" course of the *President Monroe*, south and north, had brought her for the third time into latitudes where steam heat was needed; first, when leaving New York, next, when off the coast of California, and now again in Japanese waters.

After leaving the inland sea the remaining two days to Shanghai brought smooth sea, clear sky, and temperatures low enough (50° to 55°), to be distinctly chilly when accompanied, as they were, by a northerly wind, probably the northern margin of the northeast monsoon, which in March prevails over the eastern coast of Asia as far north as Shanghai. A persistent anticyclone north of the Japanese Islands undoubtedly played a part in strengthening these northerly winds. The water temperatures were below 50° (46° to 49°). The barometer was high and steady—a spell of anticyclonic weather.

Shanghai, April 1–3.—Two days in Shanghai brought overcast sky and fresh northeast winds. The daytime temperatures ranged between 50° and 55°, but there was a very decided chill in the air because of the high humidity, the wind being off the ocean. The cold was "unseasonable," as reported to the writer by a competent meteorological authority not interested in giving the visitor an unduly favorable impression of the local weather conditions. The writer has long felt that, for the ordinary traveler, what he has called the "overcoat test" constitutes a fairly satisfactory temperature scale. It is, of course, true that people differ greatly in their reactions to cold and heat, i. e., in their "physiological temperature" sensations, but in general the "overcoat test" serves for the majority. In Shanghai a winter ulster, muffler, and gloves proved none too warm, especially when riding in an open touring car, and, indeed, were not discarded indoors in the unheated houses. Jonquils, narcissi, and magnolias were blooming in Jessfield Park, and cherry and peach trees were in blossom. The grass was not yet green. The general impression was of winter rather than of early spring, in spite of the flowers.

A visit to the headquarters of the National Research Institute, established about a year ago, emphasized the progress which is already being made in scientific research under the new Nationalist Government. With the funds now available, and with the promise of large sums in the future, the Research Institute, now housed in temporary and very crowded quarters, is planning, on a new and much larger site adjoining the French Concession, several new buildings and laboratories. The departments of physics, chemistry, engineering, and geology will be in Shanghai. The meteorological department, known as the Institute of Meteorology, is already well started in Nanking, with a new observatory and instrumental equipment, and the beginnings of a library, under the direction of Dr. Co-Ching Chu (Harvard). The Institute of Meteorology has for its purpose the collection of climatological data and the carrying on of meteorological research. It will fill the place of and perform the function of the national meteorological services of other countries. Daily weather maps are prepared at 6 a. m., and the weather conditions at Nanking are broadcast twice daily (11:30 a. m. and 6:30 p. m). Quarterly reports, beginning with January–March, 1928, have been published, and an annual report will be issued. Beginning with January, 1929, monthly reports replaced the quarterly issues, and contain the data for 20 or more stations. The biological section of the National Research Institute is also to be in Nanking. The outlook is most encouraging, the only dark side of the picture being the present political unrest in China.

A visit was made to the famous Siccawei (Zi-ka-wei) Observatory, long and favorably known among meteorologists the world over through its excellent work in connection with its typhoon forecasts. The observatory is in a settlement made by the French Jesuits in 1847, and has always been in charge of French Jesuit priests. Father Chevalier and Father Froc are familiar names to students of the atmosphere. Father Gherzi, in charge of forecasting at the time of the writer's visit, very kindly acted as conductor through the magnetic, seismographic, and meteorological departments, and explained very fully the weather map and forecast work. Two forecasts are issued daily and daily weather maps are published. Both forecasts and observations are broadcast from the observatory. Observations are fairly numerous from the Asiatic coast stations and from the Japanese and other islands, including the Philippines, but from inland stations

very few reports are as yet received. In view of the scarcity of reports and of the great delay and uncertainty in their receipt, it is surprising that Siccawei can make daily forecasts at all. In the typhoon season the situation is better. The importance of accurate and frequent observations to shipping and other interests along the seaboard insures active cooperation, and by means of radio the position, intensity, and movement of an approaching typhoon can be determined with very considerable accuracy. The success of the Siccawei typhoon forecasts is attested by the fact that the observatory receives financial support from the Shanghai customs and from the shipping companies.

The records at Siccawei and at Gutzlaff, an island off the coast near the entrance to the South Channel, show that at both stations from September to March the winds are from the north, veering from northeast to northwest (December) and then back to northeast. From April to August the direction is southeast. The monsoon influence is here seen. These varying winter and summer winds are, however, not as sharply contrasted nor as strikingly developed in this part of the China coast as the charts of January (NW.) and July (SE.) prevailing winds would suggest. The strong northwest winds of winter, blowing out from the interior deserts where the pressures are high, are well and unfavorably known in northern China, where they bring disagreeable dust storms. Clouds of dust are at times carried offshore and seriously interfere with navigation. China naturally has an east-coast continental climate, modified by the onshore rainy monsoon of summer. The winter isotherms are deflected well to the south; the north-south temperature gradient is steep; frost and snow occur everywhere, but are rare near sea level in the south.

SHANGHAI TO HONG KONG, APRIL 3–6 (852 NAUTICAL MILES)

The run from Shanghai to Hong Kong took the ship about 8° of latitude southward, through the fine weather of the northeast monsoon (force 3–5) with smooth sea, temperatures rising from below 55° to 65°, and a well-defined diurnal variation of the barometer. At this season of the year, as indicated on the March Pilot Chart, the northeast monsoon covers the China seas, the Philippines, and the eastern coast of Asia as far north as Shanghai. Off the coast of Formosa the weather is often thick and rainy and the sea rough, but on the writer's voyage all conditions were favorable.

Hong Kong, April 6.—Hong Kong's beautiful harbor, not unlike that of Rio de Janeiro, with its surrounding background of mountains, was entered in the early morning, when a light fog lay over the bay and low stratus covered the slopes and tops of the hills. By 10 a. m. the stratus had "burned off" and the rest of the day was bright and sunny, with cumulus clouds building up over the mountains. At 6 a. m., at the Royal Observatory, the temperature was 66°; the relative humidity 87 per cent. The maximum in the afternoon was slightly over 70°. For the period 1886–1928 the mean temperature in April was 70°.2; the mean daily maximum, 74°.6; the mean daily minimum, 66°.9, and the mean relative humidity, 84 per cent. At the observatory, which has an exposed location, the temperatures are doubtless lower than they are in the city proper. Thermometer readings made on board the *President Monroe* at dock were several degrees higher than the official record. Walking in the sun was uncomfortably warm and the contrast between sunshine and shade very noticeable. Hong Kong, it may be remembered, lies just inside the Tropic of Cancer. Because of its exposure to invasions of cold from the Continent, the winter temperatures are phenomenally low for the latitude. The absolute minimum for the period 1889–1928 was exactly 32°. The rainy season comes with the southeast monsoon and the mean annual rainfall is heavy (85.72 inches). Some rain also falls in winter.

A visit to the Royal Observatory proved most interesting and instructive. The director, Mr. T. F. Claxton, was absent on leave, but the observer in charge, Mr. Evans, gave the writer full information as to the work of the observatory. The daily weather map (April 6, 6 a. m.) was based on observations received from about 40 stations, including Vladivostock, on the north; Yap and Bonin Islands, on the east; and Labuan, on the south. On the Continent all stations were on the coast, reaching as far south as about latitude 12° N. A well-defined anticyclone was central between Tokyo and the Bonin Islands, and it was this pressure distribution which gave the easterly winds that prevailed on the day of the writer's visit and had also prevailed on the previous day. Usually, at this season, the southeast monsoon has already set in, and the weather is hot and muggy. In fact, some two weeks previously the summer monsoon had started, but it was temporarily displaced by the cooler anticyclonic easterly winds. The 6 a. m. forecast was for "east winds, moderate; fair; probably some fog." As at Siccawei, typhoon forecasting is the most difficult and critical work of the observatory. During the typhoon season wireless reports from vessels at sea are far more numerous than at other times; and every effort is made to secure early and frequent observations from all critical stations, and from ships. The remarkable success of the Hong Kong Observatory in making accurate forecasts of those dreaded storms is well known not only on the coast of China but among meteorologists the world over. Opportunity was given the writer to study the original files of "scratch maps," showing the earliest and the later stages of typhoon development and movement, and he left the Royal Observatory of Hong Kong with a very profound appreciation of the excellent work of that institution in making human life and property as safe as is possible in the present stage of our meteorological knowledge. Even the hurried visitor can not fail to observe the typhoon bulletin boards, placed in conspicuous places throughout the city, on which the typhoon warnings are displayed when danger is threatened.

HONG KONG TO MANILA, APRIL 7–9 (631 NAUTICAL MILES)

A thick fog, as forecast, hung over the ocean outside of Hong Kong Harbor as the *President Monroe* started at 8 a. m. on her 2-day run to Manila, and progress was very slow for about two hours until the fog belt was crossed, because scores of junks and fishing boats and several steamers were lying at anchor or creeping into or out of the bay. During the fog, which was vertically not more than 150 to 200 feet thick, some beautiful fog bows were seen, with some of their colors distinguishable. Wind-blown trees in exposed locations near the entrance to the harbor of Kong Kong showed a distinct westward deflection, under the influence, doubtless, of the summer monsoon. The rest of the run was over smooth seas, with temperatures rising to 82°; relative humidities between 80 and 90 per cent, the northeast monsoon blowing, with variable velocities (light to moderate) and the sky cloudless or, at times, partly covered with delicate

cumuli. It was the first experience on this voyage of real tropical ocean conditions. The barograph curve during the trip from Shanghai to Manila showed the general lowering of the pressure as lower latitudes were reached, with the diurnal variation throughout the week becoming increasingly marked.

Manila, April 9–10.—The short stay in Manila, unfortunately, fell in the hot season. Two uncomfortable days were spent there, with maximum temperatures of slightly over 90° on both days; minima of 73.2° and 70.2°; the tropical sun shining brightly in clear skies flecked with cumulus clouds. Walking, even in the thinnest of clothing, was uncomfortable, except early in the morning and in the evening. Soon after sunset the somewhat lower temperature and the light breeze brought some relief. The maximum and minimum temperatures during these same days at Baguio, the famous health and summer resort on the plateau, 4,640 feet above sea level, were both about 20° lower, as given in the official weather reports. It is obvious why Baguio has become so popular a place of residence, both for natives and foreigners, especially during the hottest part of the year. The northeast monsoon still held general control, but was weakening, in the transition season before the régime of the summer southwest monsoon was established. The weather map on April 9 showed a slight depression in the general region of southern Luzon—not a typhoon—and the forecast was for "variable winds in the Phillippines, those from the west quadrants prevailing in Manila; weather fair, with passing thunderstorms in the afternoon or evening." No rain fell in Manila, but lightning was observed in the northeast after dark. At Manila, which is on the lee of the island during the northeast monsoon, the wind seemed to be controlled chiefly by local conditions of land and water and of topography.

Welcome relief from the heat and glare of the sunny streets was found in the cool, darkened, high-studded library in the picturesque old buildings of the Manila Observatory, with its quiet *patio* and its peaceful atmosphere. Father Miguel Selga, S. J., the director, was most hospitable and courteous, and it was also a great pleasure to meet and have an interesting conversation with Father Corónas. The forecast work, here as at Siccawei and at Hong Kong, is greatly handicapped by the small number of reporting stations and by the delay in the receipt, by radio or cable, of the daily observations. Daily weather maps are regularly issued and two daily forecasts are broadcast. Observations from about 50 stations are included on the maps. As at the two other eastern observatories, already visited, observations and forecasts are made with much greater frequency in the typhoon season. In fact, at Manila hourly maps are drawn and hourly forecasts are sent out when a typhoon is approaching. At the Manila Observatory the writer had the satisfaction of seeing for the first time the famous barocyclonometer of Father José Algué, for many years director of that institution, an instrument which has proved wonderfully serviceable in enabling individual observers to make their own typhoon forecasts. A new, simpler, and much less expensive form of this instrument has been devised by Father Faura and this is much more widely distributed and is proving very useful. The exposure of the instruments at the observatory is good, and there has not been, and is not likely to be, any trouble because of the erection of high buildings in the vicinity. A wind velocity of 122 miles an hour has been recorded by the cup anemometer on the roof of the observatory, and the instrument which blew away in the famous Manila typhoon of 1882 was seen. In the quiet and peaceful old buildings which serve as their home, in the midst of the noise and bustle of a large city, the Jesuit Fathers at the Manila Observatory are carrying on their important work, whose scientific and practical value is fully recognized by their fellow scientists in all parts of the world.

In the late evening, just before the *President Monroe* sailed for Singapore, the writer had the pleasure of a call from Lieut. W. F. Wadbrook, United States Navy, one of a group of recently trained Aerological officers of our Navy. Lieutenant Wadbrook had been a student at Harvard in 1927–28, and is now attached to the Asiatic Fleet, with his headquarters at the Cavite Naval Base. He showed a considerable series of weather maps of the North Pacific, based on numerous reports received by naval radio stations from coast and island stations and from vessels. A closer cooperation with existing stations; a more rapid collection of the regular observations; more reports from land stations and from ships; free air data obtained by means of *ballons-sondes* and pilot ballons—these are essentials if better maps and more complete and more accurate forecasts, especially in connection with naval aviation are to be made.

Climatic controls in abundance are to be seen in and about Manila. The native hut, thatched and screened with nipa leaves to keep out rain and sun, freely open to the air, and set up on bamboo poles to raise it above the water during the rainy season, is a simple and practical dwelling for such a climate. Along the shore, between Manila and Cavite, much land was being used for the evaporation of sea water in shallow ponds separated by low earth dikes. This industry, possible only in the dry season of the northeast monsoon, is a direct response to the climate. The writer's visit having fallen in the dry season, the rice fields were dry and not yet ploughed. With the coming of the rains, ploughing and planting and irrigating begin.

MANILA TO SINGAPORE, APRIL 11–15 (1,370 NAUTICAL MILES)

The run of four and a half days from Manila to Singapore was over smooth tropical seas, with temperatures between 80° and 85° (water, 82° to 84°); relative humidities of 70 to 80 per cent; and light to moderate northeasterly to easterly winds—the end of the northeast monsoon. Cumulus clouds were dominant. There was little relief from the heat of the tropical sun, as the wind was a following one. The barometer was steady and the diurnal variation very marked. On a hot afternoon before reaching Singapore massive cumulo-nimbus clouds hung over the islands, which were plainly visible from the ship.

Singapore, April 15–18.—Singapore—"the crossroads of the East:" crossroads of many peoples and tongues; of trade routes, and commerce, and travel. Singapore was the nearest port to the Equator which was touched on the voyage. The annual range of temperature is so small as to be practically negligible; there is no warm or cold season; it is always summertime. Heat and high relative humidity characterize the whole year, but March to June are considered the most uncomfortable months. The thinnest of clothing and topees (sun helmets), are worn, and exposure to the sun should be avoided. The English and other foreign residents resort to the beaches, where breezes from the water relieve the heat, and to the outlying parts of the city, where their spacious houses with wide verandas and large windows all protected by screens against the sun, and surrounded by beautiful gardens filled with trees and flowers of extraordinary variety, provide all the comfort possible under the tropical conditions.

During the three days of the writer's visit the official records of the Government Health Office showed maximum temperatures between 89° and 90°; minima between 74° and 75°; a mean relative humidity of 81 per cent, and "maximum sun radiation" of 156°. A light breeze (SE.), blew off the bay most of the time and showed a somewhat increased velocity during the noon and early afternoon hours—doubtless a sea-breeze effect. Cumuli were the characteristic daytime clouds, and the development of beautiful massive cumulo-nimbus in great abundance even before noon, and during the afternoon, was an interesting study. Heavy tropical showers were seen falling in the distance, and one typical downpour was encountered on an automobile ride to Johore. The late afternoons and evenings brought relief from the oppressive heat, on the deck of the ship, or in the spacious open lobby of the famous Raffles Hotel, perhaps the most famous hostelry of the Far East, where east and west and north and south, meet under tropical skies and enjoy the cool breezes from the sea.

Wonderfully interesting are the motor trips through the famous "tame" rubber plantations of Singapore Island. For miles and miles they stretch, and here all stages of tree growth and of the collection and preparation of the milk-white latex can easily be studied. No more thrilling chapter in economic climatology has ever been written than that concerning the tame rubber plantations of the Straits Settlements. The importation of some "wild" Para rubber seeds from Brazil into England in the seventies; their careful cultivation in Kew Gardens; the study of the climatic and soil conditions in British Far Eastern territory; the planting of the rubber trees where suitable conditions were found to exist; the rapid expansion of the plantations; the gradual displacement of Brazilian "wild" rubber by the "tame" rubber from British and Dutch possessions in the Far East; the later attempts to control the price of rubber in the world's markets by means of the Stevenson Act—these are well-known facts in the history of rubber production. Into the holds of the *President Monroe* went thousands of boxes and bales of rubber destined for New York. As coffee is king in the Sao Paulo district of Brazil, so rubber is king in the Straits Settlements.

Within a few miles of the center of Singapore the traveler may drive through dense tropical jungle; he can see the conquest of the jungle in the recently-cleared spaces, now being planted with pineapples and bananas, and perhaps later to be used for rubber, with the newly-built native huts scattered about where but a short time ago there was an impenetrable tangle of trees and vines and creepers. On the fine roads, built and kept in splendid repair by the public works department, motor trucks carry the bales and boxes of crude rubber to the wharves at Singapore, and slow oxcarts transport loads of rattan, pineapples, bananas, and wood. Coconut palms grow in profusion, and the beauty and variety of the flowers in the gardens—hibiscus, bougainvillea, poinsettia, iris, lilies—are a constant delight. A visit to Singapore, "the crossroads of the east" is an experience never to be forgotten.

SINGAPORE TO PENANG, APRIL 18–19 (377 NAUTICAL MILES)

Through the Straits of Malacca, northward between Sumatra and the Malay Peninsula, a short trip of about 24 hours brought the *President Monroe* to Penang. The chief interest of this trip was in the splendid cumulus and cumulo-nimbus clouds over the land, whose wooded and mountainous shores and outlying islands were plainly in view all day. The steady heat (83° to 86°), continued, with a light westerly wind and some hours of calm. Steaming through the Straits of Malacca toward a wonderful tropical sunset, with a clear sky overhead, the land on both sides was dark under massive cumulo-nimbus clouds, from which heavy rains were falling. Later, for some hours after sunset, vivid lightning was seen over the Malay Peninsula to the east and over Sumatra to the west, while overhead the moon was shining brightly and the Southern Cross added its glory to the tropical sky. It was a scene the perfection of whose beauty can not easily be forgotten.

Penang, April 19–20.—Penang, with its green hills rising from the water's edge and culminating in a peak 2,700 feet high, is far more picturesque than Singapore. "The Pearl of the Orient," "The Eden of the East," "The Brightest Gem of the Eastern Seas"—these are terms which have been used by writers in describing this tropical island. Relief from the oppressively muggy heat can be found by taking an automobile trip around the island (46 miles)—a drive full of interest and quickly changing views: Palm-fringed shores and bowlder-strewn sands; rocky headlands; the crests and slopes of the hills softened by a mantle of perennial green; forests festooned with vines and parasitic plants; tall and feathery palms and tree ferns waving gently in the breeze; picturesque native huts dotted here and there, in groups or singly, on the beaches or in the deep shadows of coconut and rubber plantations; mountain streams, fed by the frequent tropical showers, leaping down to the lowlands. The road winds upward over the mountains, and from the highest point a wonderful view, not unlike that on the Pali drive at Honolulu, sweeps over the lowlands, thickly covered with coconut groves, interspersed here and there with banana trees and rice fields. To the writer, the most striking and unexpected feature of this trip was the very large amount of recent planting of rubber trees. Far up on the sides of the hills the forest has been burned off and replaced by rubber. Most of these new plantations consist of young trees, which are growing up to (estimated) heights of nearly 2,000 feet above sea level, on slopes so steep that terraces are often necessary to keep the loose sandy soil from washing away during the heavy rains. A thundershower encountered during the afternoon trip through the hills showed clearly the difficulty that arises from these downpours. It is evident that increased rubber production still seems to be a profitable undertaking in Penang, but the extent of the new acreage and the apparently unfavorable conditions of soil and slope were a surprise. From Penang, as from Singapore, the cargo was rubber and tin, while the cargo for these two ports consisted largely of American sardines, canned soups, and condensed milk.

As at Singapore, the evening brought relief from the almost overpowering heat of the day. The palm-studded lawn of the hotel, after dinner, was a comfortable spot for an interesting talk with the English manager of a large rubber estate in the interior of the peninsula. Below the sea wall the waves rolled quietly in on the beach, and far away in the distance the lightning flashes from distant thunderstorms added a tropical characteristic to the scene.

PENANG TO COLOMBO, APRIL 20–24 (1,304 NAUTICAL MILES)

From Penang to Colombo, through the waters separating the Bay of Bengal and the Indian Ocean, as was to be expected in the transition season between the winter and summer monsoons, the winds were variable, mostly

northeast and southwest, and generally light, with some calms. As compared with typical trade conditions, there were more, and more massive, cumulus clouds, developing oftener into cumulo-nimbus in the afternoon and especially about sunset, and giving frequent fairly heavy showers of short duration, usually accompanied by a slight squall wind but without lightning and thunder. The weather on two days recalled somewhat the type already familiar through previous crossings of the Doldrums. The difference in the amount, the development, and the types of the clouds at sea on different days is puzzling. With precisely similar conditions of temperature, relative humidity, and wind at sea level, the cloud conditions often vary considerably. The explanation must obviously be sought in the temperatures and wind movements aloft. For example, one day on this run was nearly overcast with cirrus and cirro-stratus, there being only a few rudimentary cumulus all day. Again, as often before, the growth of heavy cumulo-nimbus clouds after sunset, by radiation upward, was several times seen. "Cat's-paws" of wind roughened the surface of the sea at intervals. Temperatures and humidities naturally continued high (82° to 86°; 75 to 80 per cent), and the barograph showed nothing beyond the diurnal variation. The Penang-Colombo run provided some wonderful sunsets, with the margins of the towering cumulo-nimbus brilliantly illuminated long after the sun had disappeared below the horizon, the moon, nearly at the full, shining in almost clear skies after the clouds of the day, having provided constant variety and enjoyment during the hours of their lifetime, had ended their ephemeral existence.

Before reaching open waters, while steaming through the northern end of the Straits of Malacca, the wind was very light and variable, and the sky heavily clouded because of the abundant growth of massive cumuli over the mainland and the islands. The heavily forested mountain slopes of the northern end of Sumatra, easily seen from the ship, bore witness to the abundant rainfall.

Colombo, April 24.—The one day spent in Colombo brought a beautiful example of heavy tropical rains. From the deck of the steamer lying at anchor in the harbor, the development of massive thunderstorm clouds over the land had for some time been watched with interest. By 2:30 p. m. thunderstorms of wide extent, with vivid lightning, were in active operation. At 3:45 p. m., with a sharp squall, and a fall of temperature of 4° to 5°, the rain came across the harbor, pouring in torrents, obscuring the view even over relatively short distances. The passage of the squall had no observable effect on the barograph curve. For four hours, with slight intermissions, and with varying intensity, the rain continued. After the first downpour and squall, with a little lightning and thunder, the precipitation had the character of a general, heavy, nonthunderstorm rain. The loading of the cargo of rubber, tea, and coconut oil, was interrupted, and the native stevedores found refuge on the ship's decks, or in the cargo lighters. Similar afternoon and early evening rains were reported to have occurred on several preceding days, and the Colombo Observatory stated that "liability to rain is still present." In the Colombo Independent of April 24, with reference to the construction of certain new buildings at the Tea Research Institute at Nuwara Eliya, the hill-town par excellence of Ceylon (6,199 feet), it was stated that, "owing to the bad weather conditions, the building of the various laboratories and other bungalows is not to be taken in hand till September." Ceylon being an island, with a hilly topography, its rainfall conditions are somewhat complex. Both monsoons cross water before they reach it. Hence the common distinction between "dry" and "rainy" monsoons is not rigidly applicable here. Furthermore, the amounts, and even the seasons, of precipitation are to some extent controlled by exposure and by altitude. The official records of the Colombo Observatory show mean annual rainfalls ranging from 151.50 inches at Ratnapura, to 38.80 inches at Mannar. Colombo has 87.10 inches.

Ceylon, "the Pendant Jewel of India"; poetically described as resting "on the ocean like an emerald in a setting of silver," lies just southeast of the southern end of the peninsula of India, in about the same latitude as the Panama Canal. The through round-the-world voyager can not arrange his time so that his stops in the different ports will all come in the best season. From about the end of November to the middle of March is considered the most favorable season in Ceylon. By April and May it is hotter, and later on come the rains. The maximum temperature recorded by the writer during his day in Colombo was 85.5°, and the maximum relative humidity, 78 per cent. These observations were taken on board, with a fresh wind blowing from the ocean. In the city, the conditions were far less comfortable, and recalled Manila, Singapore, and Penang. Coconut groves in abundance may be seen in the environs of Colombo, and huge iron drums of coconut oil formed part of the cargo for New York. The famous Ceylon tea plantations are at elevations greater than those visited by the casual tourist, who usually limits his hill excursions to one trip, to Kandy (75 miles, 1,600 feet), on which some tea, and many varieties of spices (nutmeg, cinnamon, cloves, etc.), and of other tropical vegetation may be seen. Rubber trees are also cultivated, and "Product of Ceylon" was marked on many cases of rubber which were stowed in the holds of the *President Monroe*. Not far from Kandy, in the Royal Botanical Gardens, important experimental work has been done in connection with the introduction, into the British Far Eastern possessions, of Para rubber, of cinchona, and of cocoa.

COLOMBO TO SUEZ, APRIL 24–MAY 6 (3,394 NAUTICAL MILES)

From the Orient—Kipling's "East of Suez"—back to the Occident; from Colombo to the port of Suez, at the southern entrance of the famous canal, was the final run through tropical waters. Five and a half days of quiet steaming across the calm Arabian Sea, in the transition season between northeast and southwest monsoons, to the entrance of the Gulf of Aden, bring memories of glorious tropical sunsets, and of wonderful moonlight tropical nights. It seemed almost as if nature had planned to have the final impressions of the Tropics superlatively favorable. In April and May, because of the increasing warmth over the adjacent continental area, the northeast (winter) monsoon weakens, and is replaced by light and variable winds, with an increasing percentage of calms. The northern limit of the southeast trades in April is still south of the Equator. The southwest monsoon has not yet set in. April is not a month of tropical cyclones, although, according to the pilot chart, occasional storms do develop, in the last part of the month, over the central or southeastern part of the Arabian Sea, and move northeastward or northwestward. During the writer's voyage the winds varied between southwest and northwest, with a preponderance of the latter direction, and with velocities ranging from fresh to light. Calms were not infrequent, but never lasted more than a few hours at a time.[6] Tropical temperatures of

[6] The percentages of calms vary between 17 and 25, according to the pilot chart.

80° to 86° and high relative humidities were rendered reasonably comfortable because of the westerly winds which blew most of the time, and also by the fact that the ship herself was steaming westward. The clouds were as interesting as any that had been observed up to that time. Typical marine cumuli were conspicuously infrequent, and cirro-stratus took their place. Some days were nearly overcast and resembled dull gray days in home latitudes, but brought no rain. Some days were almost cloudless. Short, light showers, from rudimentary cumulo-nimbi, fell a few times. It was noted that the relative humidity on days with few or no cumulus clouds was usually lower (mean 65 per cent) than on the days with many cumuli.

Cape Guardafui, the northeasternmost point of Africa, at the eastern entrace to the Gulf of Aden, was passed five and a half days after sailing from Colombo. Its bold, rocky headlands and its great wastes of yellow sands made a striking picture in the brilliant noon sunshine of a hot tropical day. The impression was predominantly that of aridity, and inevitably brought to mind the desert strip of Somaliland which, reaching southward along the eastern coast of Africa, is such a striking feature of the mean annual rainfall map, standing out sharply in contrast with the very heavy rainfall of equatorial Africa farther west. This strip of land, lying in latitudes of otherwise generally abundant precipitation, is unfortunate in its position with regard to the prevailing wind directions. Both monsoons, the northeast and the southwest, blow parallel with, and not against, the coast. The visibility was good in the vicinity of Cape Guardafui when the *President Monroe* passed it, but during the southwest monsoon, in summer, the sand and dust blown offshore by the strong wind often produce a very thick and hazy condition which makes navigation in these waters difficult and even dangerous. The few small and scattered settlements visible from the deck were on the yellow beach sands; sad and lonely homes they seemed for human beings. Some trees have been planted in the larger villages, doubtless under irrigation. The hills behind are sparsely covered with scrubby vegetation, and here and there lines of trees could be seen, through the glass, extending up the ravines and gullies where more moisture is available for their growth.

The narrow bodies of water between Asia and Africa—the Gulf of Aden and the Red Sea—are interesting from many points of view. The lands adjacent to them have played no inconsiderable part in history. An immense volume of the world's commerce daily passes over them. And climatically they are breaks in the great trade-wind desert belt of northern Africa and southwestern Asia and, since the opening of the Suez Canal, have formed an easy water highway across vast stretches of forbidding sands.

The Gulf of Aden and the Red Sea have long been dreaded, both by ships' crews and by passengers, because of their traditional heat. High temperatures, certainly during most of the year, are to be expected. Relatively low latitudes, prevailingly clear skies and brilliant sunshine, surrounding deserts, and warm waters all make for high temperatures. Massaua, on the western shore of the Red Sea, is one of several stations in the Tropics with the reputation of being "the hottest place in the world." Yet much of the general dread of the Red Sea by present-day ocean travelers is psychological. While the heat is by no means altogether imaginary, it is not unbearable by those who sit quietly on deck in the shade and in the breeze. The story is quite different for the men in the engine room or who are otherwise employed below decks. The writer's voyage across these waters came early in May, before the time of the greatest heat, although there is but little seasonal difference. In the Gulf of Aden temperatures (84° to 87°) and humidities (over 70 per cent) were similar to those experienced throughout the trip from Manila. Yet the heat often seemed more oppresive, doubtless because the winds were light and variable in direction. In the colder months the winds are prevailingly northerly—the northeast trade and the northeast monsoon—and have higher velocities. The days of intense suffering among the stokers in the engine rooms are fortunately passing with the coming of oil-burning steamers, but it may be noted that the wet-bulb readings, here and throughout most of the voyage in the lower latitudes, were over 75°, only a very few degrees below the wet-bulb reading of 80° which at least one authority has set as the upper limit of endurance of strenuous physical effort by the white man.

Aden, with its jagged mountain peaks and its desolate arid slopes, was passed at sunset. In spite of its nakedness, the rocky headlands were soft and picturesque through the bluish haze of a beautiful tropical afternoon. Later, in the twilight, the lights of the town began to twinkle on the slopes, and still later, in the rapidly oncoming darkness of the tropical night, Aden's two revolving lights could be seen, flashing their message of encouragement or of warning, as the *President Monroe* steamed on her course toward the Straits of Bab-el-Mandeb and the Red Sea.

So far as the writer's own experience with weather conditions in the Red Sea was concerned, the heat was no more oppressive than it had been during much of the voyage in the Tropics. Over the southern portion of the sea the temperatures were several degrees higher, the wind was lighter and more variable in direction, and when there was a following breeze the heat naturally seemed greater. There were also a good many hours of calm. On the other hand, over the northern half of the sea the temperatures were slightly lower, and northerly winds prevailed, at times sufficiently strong to produce "white caps." The temperatures averaged 84° to 86° during most of the passage, the maximum observed by sling psychrometer being 86°.[7] During the last two days, as higher latitudes were entered, and with fresh northerly winds, the temperatures fell to 80° and even slightly below 80°, except during the noon hours. The coming of cooler weather was evidenced by the less constant use of electric fans on board and by the gradual appearance of somewhat darker clothing after sunset.

The Red Sea passage unfortunately brought no dust storms, which are of frequent occurrence when a strong wind carries the sands of the surrounding deserts over the water, and which it would have been interesting to experience. On the other hand, a wholly unexpected meteorological experience fully compensated for the lack of a dust storm. This was a light shower of rain. The day had been more or less overcast, with cirrus and cirrostratus, later followed by alto-stratus and nimbus, the sky having the appearance of a gray afternoon in "temperate" latitudes, with rain in prospect. Indeed, the wave alto-stratus would, in higher latitudes, have been taken as a very good prognostic of rain within a few hours. Soon after sunset a light shower fell, with a northerly breeze, unaccompanied by any squall, or irregularity in the barometer curve, or lightning, or thunder. This occurred in about latitude 16° N. No cumulus clouds were observed during the trip across the Red

[7] The reading of 92°, entered in the ship's log, was certainly too high—the result of carelessness on the part of the quartermaster.

Sea. The cirri forms (cirrus, cirro-stratus, cirro-cumulus) and alto-cumulus replaced them, sometimes completely covering the sky. The absence of cumuli is to be attributed to the fact that the temperatures aloft, at the cumulus level, were too high for local instability. The lapse rate was against convection. Certainly, the temperatures of the lower air and relative humidities (70 to 85 per cent) were just as favorable as those which accompanied the development of abundant cumulus clouds over the open ocean. Clear or cloudless skies were the prevailing condition.

The short run of a few hours through the Gulf of Suez gave many views of the rugged, barren mountains in the background, the sandy wastes, and the nearby arid islands, softened by the yellowish haze of daytime and the purplish haze of sunset and twilight.

THE SUEZ CANAL (88 NAUTICAL MILES; 1 DAY)

The Panama Canal is in a region of abundant, even excessive, tropical rainfall. Many of the engineering problems met with in its construction and operation concern the control and proper utilization of these rains. The Suez Canal crosses a desert. Loose, drifting desert sands were, and are, the key to many of the engineering difficulties here met with. The contrast between these two strikingly different climatic regions is especially marked when a continuous round-the-world voyage takes the traveler through both canals on one trip.

Many, probably most, of those who steam through the Suez Canal doubtless find the 10 hours or so spent on the canal tedious—a monotonous waste of time if the passage is made by daylight, but no one who wishes to see wonderful desert scenery and fully to appreciate what man has here accomplished should take the trip at night. To the present writer the day was one crowded with interest. It is true that there are miles upon miles of absolute aridity, the yellow sands of the desert stretching as far as the eye can see. But there are varying lights and shadows, and picturesque sand dunes, and mirages, and here and there great white fields of salt. The traveler, seated comfortably in his steamer chair, can come very close to the spirit of the desert. And then there are many other rapidly-changing views—of green fields, and of trees, and of scattering settlements where man has provided a water supply for irrigation in the famous Fresh Water Canal; of the neat buildings and signal stations of the canal company; of the varied activities of the laborers as they repair the masonry and continue the never-ending dredging operations. Then there are the barbed-wire entanglements and the ruins of temporary encampments in the desert, which recall the days of the Great War when the Turks were threatening an attack on the canal; and the impressive war memorial, built on the western bank, which will forever stand as a monument to British valor and British achievement. Four decades ago the writer saw the Suez Canal. In that time there have been many changes, but the most striking of these are the increase in the amount of irrigation, and especially of the numbers of trees along the western side of the canal and the construction of the new railroad across the desert to Palestine. It was very interesting, at East Kantara, to see the passengers arriving by train from the East and then taking the ferry across the canal, to connect with the railroad for Cairo, Port Said, and Alexandria. Four decades ago such a development of desert travel was not even thought of.

The day of the Suez Canal trip began with a wonderful sunrise over the eastern desert hills. The air then was delightfully cool and refreshing. As the day advanced, the temperature rose, and reached 88° at noon, the sun shining brilliantly in a sky cloudless except for a few scattering cirrus. In the early afternoon the wind blew in gusts from the hot sands of the desert, and the temperature rose to 102°, as observed by means of the sling thermometer. This instrument was graduated only up to that point. It is probable that the actual temperature was even higher. In the later afternoon (5:30 p. m.), with the sun approaching the western horizon and obscured by a veil of cirrus and cirrostratus, 80° was recorded. Finally, at Port Said, with a fresh northerly wind, 75° was noted at 9 p. m.—a refreshing change, which necessitated warmer clothing. An evening at anchor off Port Said is an experience well worth the delay which it causes in the hurried trips of most travelers. Here are all the varied activities of a busy port; the loading and unloading of cargo; the coaling, still done by the steady stream of laborers carrying the baskets of coal on their backs, and in addition, the succession of steamers, each one equipped with a powerful searchlight, moving slowly and very silently into or out of the canal.

THE MEDITERRANEAN, PORT SAID TO MARSEILLES [8]

The fresh, cool, invigorating breezes of the Mediterranean brought a distinct sensation of well-being and of energy after the month spent in the damp heat of the Tropics. Temperatures fell gradually from a few degrees over 70° to slightly over 60°. With the exception of a few hours before reaching Marseilles, when a strong northwest gale blew and the sea became disturbed, the winds were light to moderate, mostly northwesterly, and the sea perfectly smooth, with fair to cloudless skies. The Mediterranean was at its best. The barograph showed only slight fluctuations. There were no well-developed cyclonic depressions. The season of winter storms was over. Under such favorable conditions it is easy to see why the Mediterranean peoples so early became sailors. Their difficulties came, not during the summer months, when the winds are fairly regular and reliable, but in winter, when well-developed storms sweep across the sea, with strong and changeable winds and rough water. At Naples the writer was fortunate in experiencing a "wet sirocco," with overcast skies followed by showers. The clouding up and the clearing were perfectly characteristic of an ordinary Temperate Zone cyclonic disturbance, but the barometer indicated only a very slight depression; the winds were light, and the showers of short duration. It was late in the year for "winter rains" in Naples. A good northwest wind followed the rain during the first few hours of the voyage from Naples to Genoa, and lightning was seen along the wind-shift line.

Mount Etna was an impressive sight, as it towered up majestically with smoke or "steam" columns rising from its crest; its outlines softened by the bluish sunset haze, and the sun setting behind a low bank of clouds whose golden upper edges were sharply marked against the sky. The "steam cloud" from Mount Vesuvius, with its changing height and form, was an interesting study. At times it threw up great cumulus heads, which broke off, blew away, and dissolved. At other times it rose almost vertically, as a uniform column. And again, it was blown almost horizontally by the wind, resting on the summit, and extending down the lee side like a cloud cap.

[8] The ports and distances in the Mediterreanean were as follows: Port Said to Alexandria, 156 miles (12 hours); Alexandria (1 day); Alexandria to Naples, 1,007 miles (3 days); Naples (1 day); Naples to Genoa, 333 miles (1 day); Genoa (1½ days); Genoa to Marseilles, 200 miles (¾ day); Marseilles (½ day).

While on shore, in Alexandria, Naples, and Genoa, it was somewhat warm during the noon hours when walking in the sun, but cool breezes from the Mediterranean provided relief. The view over the wonderful Bay of Naples from the hills behind the city was somewhat obscured by a haze, but was soft and very beautiful for that reason. And at Genoa there was again occasion to note the favored location of that far-famed stretch of coast, which includes the Italian Riviera and the "Cote d'azur" of France. With the mountain barrier on the north as a protection against invasions of severe cold, and the southern slopes facing the sun and the Mediterranean, this coast well deserves its reputation as a health and pleasure resort, although winter visitors are often disappointed when they experience the not infrequent winter storms and chilly days which accompany them.

To the climatologist, wandering around the world in search of weather, the occurrence of a violent mistral in the vicinity of Marseilles was a very interesting and instructive experience. This wind, analogous in many respects to the cold or cool wave of the eastern United States, is one of the scourges of the lower Rhone Valley, and of the adjacent districts at the head of the Gulf of Lyons. Blowing with high velocity, often for many hours at a time, it is not only a very disagreeable feature of the weather in this region, but is a real handicap to crops and trees, and has caused many marine disasters. High walls and windbreaks are resorted to in order to protect gardens and orchards and crops. On the writer's trip, after a peaceful and uneventful crossing of the Mediterranean from Port Said to Genoa, a stiff northwest gale was encountered a few hours before reaching Marseilles; the sea became rough, and the temperature fell. So violent was the wind, especially during the frequent heavy squalls, that it was impossible to enter the harbor of Marseilles through the narrow entrance between the two breakwaters, or to maneuver the vessel within the harbor in view of the great congestion of shipping there. Under these conditions, the *President Monroe* was forced to anchor in the bay, where she lay 18 hours in company with several other steamers in a similar situation. Finally, in the early morning when the gale had moderated slightly, with the aid of three tugs, the steamer was brought safely in to her dock, although more than once it seemed inevitable that she must put to sea again and postpone the attempt.

The Marseilles morning paper gave the names of several steamers at anchor in the bay, awaiting "une accalmie pour entrer dans nos bassins"; and reported "hier, dans notre golfe, la mer était tres agite par vent fort d'Ouest-Nord-Ouest." The official temperatures at Marseilles during the previous day were 69.1° for the maximum and 57.2° for the minimum. The sky was clear; the pressure 29.929 inches in the morning and 29.858 inches in the evening; the wind northwest, "fort." The writer's observations, on board ship, at the dock, varied between 57.5° and 61°. The barograph throughout the mistral showed surprisingly little change. There was a slow and very slight rise during the earlier hours, and then a similarly slow fall, with sudden sharp irregularities during the more severe gusts. The high blustering wind and the dust were very disagreeable during a brief excursion on shore in Marseilles, and when the *President Monroe* steamed out of the harbor in the afternoon there was still considerable danger of her being blown against the breakwater, or of her colliding with other vessels lying at the docks. A few hours of westward steaming and the gale was left behind; the Mediterranean again became calm and peaceful; there was a distinct relief from the blustering turmoil of the past two days. It was this mistral which was encountered by the *Graf Zeppelin* on her flight to New York, and forced her down in France.

MARSEILLES TO NEW YORK, MAY 15–28 (3,913 NAUTICAL MILES)

As the *President Monroe* steamed westward on the last stage of her voyage, the snow-covered mountains of Spain brought to mind the importance of the winter snowfall in providing the water necessary for irrigation in southern Spain. Snow water was there utilized, with marvelous skill, in the days of the Moors, as it is still used by the Spaniards to-day. As the snows on the high Sierras of California supply what has well been called the "lifeblood" of that State, so do the snows on the Spanish Sierras furnish water for the fields, and gardens, and orchards of southern Spain. The famous Rock of Gibraltar was passed on a gray, showery afternoon. The "Key to the Mediterranean" is always impressive, because of its own ruggedness and strength, and even more because of the unseen power of its hidden guns and munitions of war. It adds very greatly to the value of Gibraltar as the "eyes" of the Mediterranean that the rock is not in a region of frequent dense fogs. The passage of vessels into and out from the Mediterranean can therefore be watched by the British guardians of that massive fortification under conditions of visibility which are generally highly favorable.

After passing the Straits of Gibraltar for about half the voyage to New York the pressure control was anticyclonic; the winds mostly moderate to fresh northwesterly; the temperatures slightly below normal (60 to° 65°), with varying amounts of cloud. The pressure reached 30.50 inches, and one vessel not very far away reported 30.62 inches. According to the general synopsis of North Atlantic weather brodcast by the *Jacques Cartier*, the French training ship, which is also a most valuable central meteorological station, there were two well-marked anticyclonic centers, one east and one west of the Azores. It may be noted that the pressures observed in these latitudes were very much higher than those shown on the pilot chart as the normal readings in the North Atlantic high during the month of May. This condition once more emphasized the fact that too much stress should not be laid on the normal monthly pressures over the great oceanic anticyclonic areas. These high-pressure belts, or centers, are constantly being encroached upon, or invaded, by moving anticyclones and cyclones, which cause considerable fluctuations in the pressures and bring variable winds. Mean or normal isobaric maps, valuable as they are, should not receive too much emphasis. Irregular controls must also be taken into account.

The course followed by the *President Monroe* took her close to the south coast of the island of San Miguel, the largest of the Azores, on a beautiful sunny day, with clear sky and a fresh westerly wind. As this wind was forced upward over the San Miguel Mountains, it produced wonderful cloud caps and banners, the latter trailing off for some distance to leeward, and also showing clearly the dissolution of some of the clouds as part of the air current descended on the lee side of the higher mountain tops.

The rest of the trip, after leaving the Azores, brought many illustrations of the North Atlantic's varying moods; strong, chilly northwesterly winds and rough seas on steep anticyclonic gradients; mild, squally, and rainy

southerly winds and disturbed seas when cyclonic depressions passed eastward over the Newfoundland area; some peaceful days, with bright sunshine and gentle winds; a few hours of fog. A maximum temperature of 68° was recorded during a strong southerly wind. A minimum of 52° came with a gusty northwest wind, the water then being 51°. A change of wind, from northwest to southwest, brought a rise in temperature from 52° to 66°. To the ocean voyager who is meteorologically inclined, and who has the privilege of free access to the captain's quarters and the chart room, a trip across the North Atlantic at the present day is full of interest. He can read the weather reports sent in by other vessels, and during the ice season there is added interest in the regular broadcasts sent out by the United States Coast Guard cutter on ice patrol. If the *Jacques Cartier* is on cruise, he sees the excellent synopsis of general weather conditions which she broadcasts to all vessels. And he also has the opportunity to study the forecasts for the eastern United States and the adjacent waters broadcast from the Arlington station. How different were the conditions four decades ago, when the writer crossed the North Atlantic on a small sailing ship to the Azores and Madeira, and was absolutely without any word from vessel or from land for a month at a time! There is never monotony at sea. Even in the everlastingly hot and steaming Tropics there are constant changes in cloud forms and shadows, and in the wonderful beauties of the sunsets. Far more frequent and varied are the moods of the northern oceans, in the belt of the stormy westerlies, with their incessant alternations in temperature, in cloudiness, in wind—a never-ending interest to even the least observant ocean traveler.

The *President Monroe* anchored at the quarantine station in New York harbor at sunrise on a beautiful morning at the end of May. Slowly she steamed up the harbor to her pier. Her long voyage of nearly 30,000 miles, westward around the world, was happily ended. With renewed inspiration for his work; with enlarged views and a clearer understanding of the wonderful operation of nature's great atmospheric machinery, the writer's "wandering in search of weather" was brought to a successful close.

REFLECTIVITY OF DIFFERENT KINDS OF SURFACES

551.593

By HERBERT H. KIMBALL and IRVING F. HAND

[Weather Bureau, Washington, July 18, 1929]

The reflection measurements given in Table 3 of this paper were made by Mr. Hand from a Douglass O. H. plane, *The Dipper*, equipped with a Liberty motor, and piloted by Army air pilots from Bolling Field, D. C. Authority for the flights was obtained by the Secretary of Agriculture through the Secretary of War.

The photometer was designed especially for this purpose by Dr. L. F. Richardson, London, England, and is one of four constructed by Messrs. R. W. Munro with funds provided by the Bureau of the Meteorological Section, International Geodetic and Geophysical Union. A full description of the instrument and the method by which it has been standardized will be found in a paper by Richardson in Union Géodésique et Géophysique Internationale, Section de Météorologie. Troisième Assemblée Générale: Prague, 1927. Cambridge, 1928.

Briefly stated, the photometer has two windows—a small one of fixed diameter through which light is admitted from the sky, and a large one with an iris diaphragm that permits its diameter to be varied by the observer until equal illumination is obtained from the two sources under comparison. In the case under consideration the second source is reflection of skylight from the ground, and the proportion of light reflected is given by the ratio $\frac{A_s}{A_g}$, where A_s is the area of the window pointed toward the sky and A_g that of the window exposed to the ground. The area A_g is a function of a dial reading near the eyepiece of the photometer, which records the number of turns of a worm wheel that opens and closes the iris diaphragm.

Munro photometer No. 3, which was allotted to the United States Weather Bureau, was received in Washington late in 1927. Some preliminary readings were made from the ground during the winter of 1927–28, and are given in Table 2. Additional measurements made from a snow surface gave unsatisfactory results, since the instrument is not designed for measurements from highly reflecting surfaces. A neutral gray screen with a transmission of 0.49 ± 1 per cent has been obtained from the research laboratories, physics department, Eastman Kodak Co., for use in future measurements from snow and other highly reflecting surfaces.

Doctor Richardson has pointed out in his paper, above referred to, that the relation between the reading of the photometer dial and the diameter of the projection of the iris opening from the white photometer wedge, and which is measured by a scale etched on glass provided with the instrument for that purpose, may change from time to time. In Table 1 are given the original calibration by Richardson, a calibration made at the United States Bureau of Standards, and two calibrations made by the authors with a focusing flashlight. For a dial reading of 20 with the iris closing, calibrations No. 1 to No. 4 give reflections of 0.036, 0.026, 0.029, and 0.027, respectively, and for a dial reading of 25, also with the iris closing, reflections of 0.150, 0.074, 0.087, and 0.078, respectively.

From the above it is evident that the determinations of the relation between dial reading and iris opening are of the first importance, and one can not be sure that the relation does not change during a series of observations. In connection with the measurements here presented it has been assumed that the Bureau of Standards calibration (No. 2, Table 1) applies to the few readings made on January 3, 1928, and May 13, 1929; the calibration of May 20, 1929 (No. 3, Table 1) to the readings of May 14 and 21, and the calibration of June 5, 1929 (No. 4, Table 1), to the readings of June 3 and 24. Calibration readings have therefore been made to apply to series of observations that most closely precede and follow the date of the calibration.

The photometer was rigidly attached to the side of the cockpit of the airplane, so that when the plane was in its flying position the upper or sky window of the photometer received light from the zenith at normal incidence, and the lower or ground window, at normal incidence from the ground. No part of the plane could shade either the sky window or the ground window of the photometer.

The plane was usually flown at an air speed of from 95 to 110 miles per hour, which, when referred to the ground,